Beneficial Use of CO_2 in Precast Concrete Products

Background

In an effort to reduce carbon dioxide (CO_2) emissions from various industrial and power generation processes to the atmosphere, the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) is currently funding research intended to advance current state-of-the-art technologies that addresses the use or reuse of CO_2 in a variety of different economic and industrial processes.

Carbon dioxide utilization efforts focus on pathways and novel approaches for reducing CO_2 emissions by developing beneficial uses for CO_2 that will mitigate greenhouse gas emissions. Utilization of CO_2 is an important component of carbon sequestration and applicable approaches include conversion of CO_2 into useful chemicals and polycarbonate plastics, storage of CO_2 in solid materials having economic value, indirect storage of CO_2, and other breakthrough concepts.

Critical challenges identified in the utilization focus area include the cost-effective use of CO_2 as a feedstock for chemical synthesis or its integration into pre-existing products. The efficiency (CO_2 integration reaction rate and the amount of CO_2 sequestered in a product) and energy use (the amount of energy required to utilize CO_2 in existing products) of these utilization processes also represent a critical challenge. This project will focus on the beneficial use of CO_2 in precast concrete products.

Project Description

Researchers at McGill University are working to develop a CO_2 curing process for the precast concrete industry that can utilize CO_2 as a reactant to accelerate strength gain, reduce energy consumption, and improve the durability of precast concrete products. Carbon dioxide curing of concrete is considered a CO_2 sequestration process as gaseous CO_2 is converted to thermodynamically stable calcium carbonate which is embedded in calcium silicate hydrate. Concrete masonry blocks and fiber-cement panels are ideal candidate building products for carbon sequestration since they are mass produced, and require steam curing. In order to make the process economically feasible, self-concentrating absorption technology will also be studied to produce low cost CO_2 for concrete curing and to capture residual CO_2 after the

CONTACTS

John Litynski
Sequestration Technology Manager
National Energy Technology Laboratory
626 Cochrans Mill Road
P.O. Box 10940
Pittsburgh, PA 15236-0940
Phone: 412-386-4922
john.litynski@netl.doe.gov

Darin Damiani
Project Manager
National Energy Technology Laboratory
3610 Collins Ferry Road
Morgantown, WV 26507
Phone: 304-285-4398
darin.damiani@netl.doe.gov

Yixin Shao
Principal Investigator
McGill University
817 Sherbrooke Street West
Montreal, Quebec, Canada H3A 2K6
Phone: 514-398-6674
yixin.shao@mcgill.ca

PARTNERS

3H Corporation

PROJECT DURATION

Start Date
10/1/2010

End Date
9/30/2012

COST

Total Project Value
$499,890

DOE/Non-DOE Share
$399,890 / $100,000

curing process. The compact design of the CO_2 chamber and low cost carbon capture technology should result in a net process cost of less than $10 per ton of CO_2 sequestered. The proposed research will examine the possibility of achieving a cost-effective, high performance concrete manufacturing process through a prototype production using specially designed chambers, called CO_2claves, to replace steam kilns and implement forced-diffusion technology to maximize carbon uptake at a minimal process cost.

The experience gained will help promote application of the process to other products in the precast concrete industry to enhance CO_2 utilization capacity. Although the project is still at laboratory scale, it is a complete study of prototype production and can be implemented by scale-up.

Goals/Objectives

The goal of the project is to integrate CO_2 into various precast concrete forms that consume less energy, generate minimal CO_2, and have high performance. This project will be an interdisciplinary laboratory/engineering simulation process study with the following focus areas:

- Design and testing of CO_2 claves for concrete blocks and panels: The design and fabrication processes used to create these reaction chambers will replace existing concrete production curing processes and implement an innovative technology to maximize CO_2 uptake into the concrete structure at a minimal cost.
- Conduct concrete manufacturing process experiments with commercial sources of CO_2: Concrete blocks and panels will be fabricated at varying specifications and at a range of processing parameters to validate the design of the CO_2 claves, the CO_2 uptake, and the economic value of the process implemented during initial laboratory tests.
- Performance evaluation of the carbonated products: Short-term (immediately after curing) and long-term (after 28-day subsequent hydration) performance evaluations will be conducted on carbonated products made using commercially produced and recovered gas. Performance parameters will include multiple physical and mechanical properties. Microstructure analysis will show if a carbonate bonded matrix has been formed. Comparisons will be made with commercial products to determine if the new process can be further optimized.
- Production of carbonated products with recovered CO_2: Carbon dioxide for use in manufacturing precast concrete products will be produced and captured using self-concentrating absorption technology. Carbon dioxide will be recovered for use from flue gas generated from a power plant or from the cement plant.

Benefits

Precast concrete products are considered green building products because of their superior performance, minimal environmental impact, quick manufacturing turnaround, and reduced life cycle costs. Precast concrete can be an even more environmental friendly green building product if CO_2 is used to replace steam in the curing process. Carbon dioxide curing is caused by a chemical reaction between the cement binder and CO_2 early in the concrete production process. This process makes precast concrete products stronger, less porous, and more durable. The production cycle is also significantly shortened when CO_2 is used in the curing process instead of steam.